Networked Sensors for the Objective Force
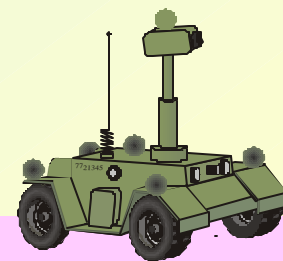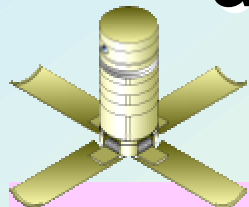
"No Place To Hide"

John Eicke
U.S. Army Research Laboratory

Objective

Demonstrate a family of low cost sensors utilizing a wide range of sensor types, to enable overarching situational awareness & provide a common operational picture across all echelons of the future Army.

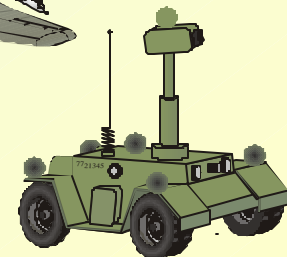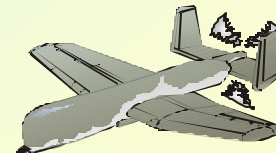*Networks of ubiquitous, low cost sensors can "see" where we currently cannot!*
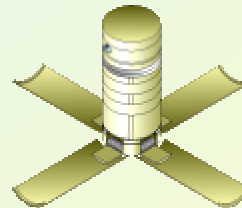
APPROVED FOR PUBLIC RELEASE

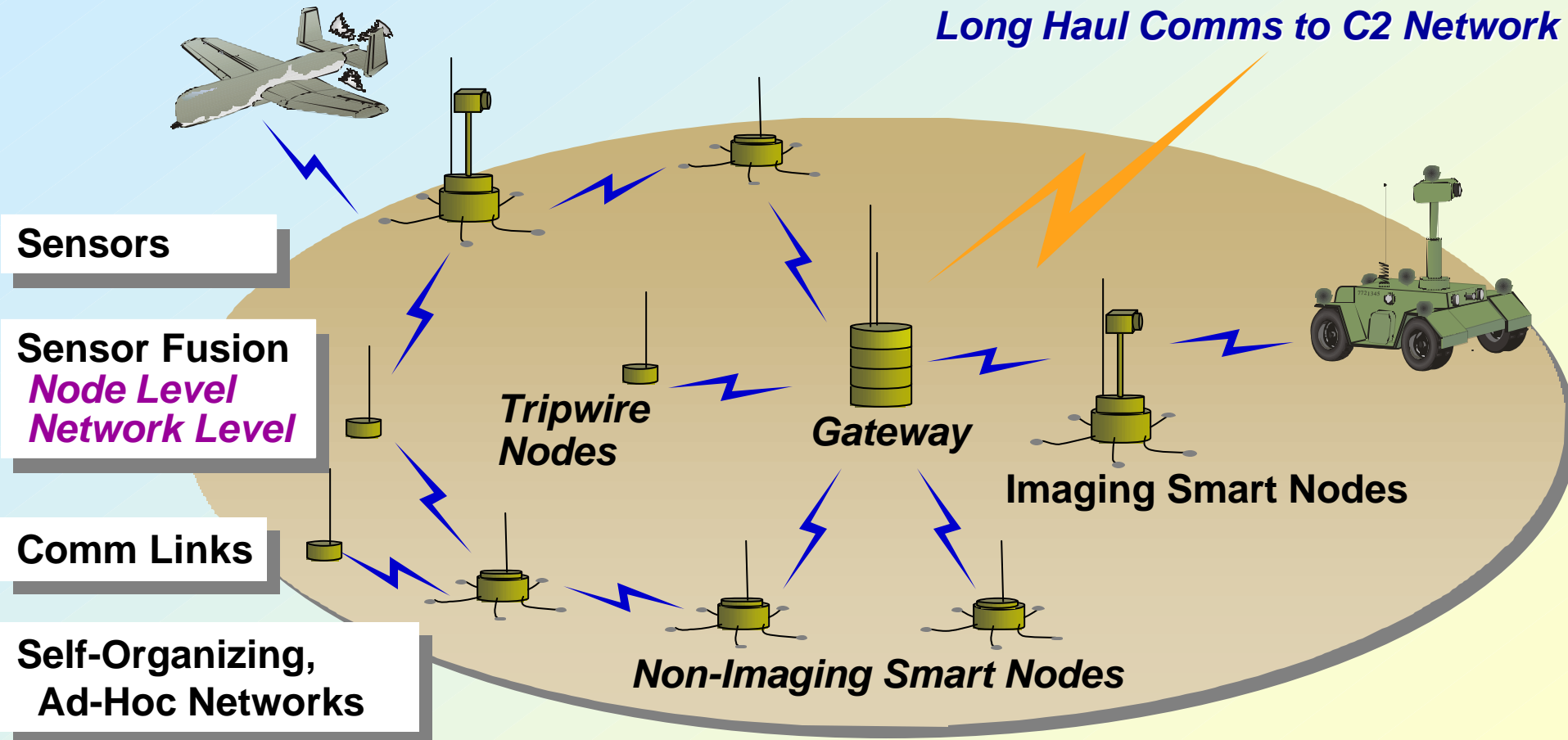# Networked Sensors for the Objective Force ATD

- **Approved ATD in 2002**

- **4 year duration**

- **CECOM-NVESD Lead – ARL supporting**

- **Aimed at insertion into FCS Block II**

- **Components:**
  - *UGS*
  - *UAV mounted sensors*
  - *Robot mounted sensors*

What's the Concept ?

ARL

Long Haul Comms to C2 Network

Sensors

Sensor Fusion
Node Level
Network Level

Comm Links

Self-Organizing,
 Ad-Hoc Networks

Tripwire Nodes

Gateway

Imaging Smart Nodes

Non-Imaging Smart Nodes

The network is the sensor !

What Does This Mean to the Warfighter ?

- **High fidelity** sensor information for
    - *Targeting*
    - *Threat detection*
    - *Battle damage assessment*
- **Affordable**, organic sensing at the small unit & soldier level
- **Multi-mission** target & threat information for a wide range of needs
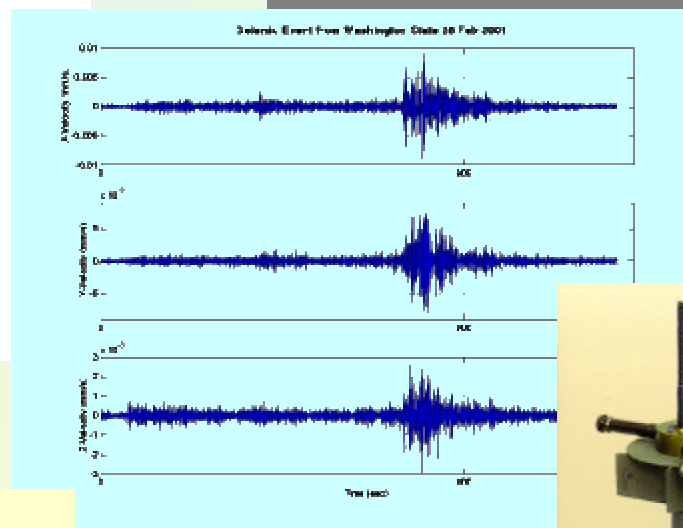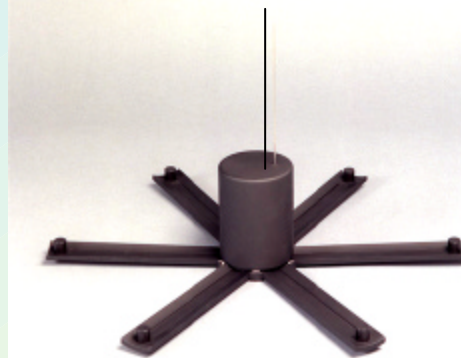- **Integrated** with other sensors to provide a more complete picture of the battlespace
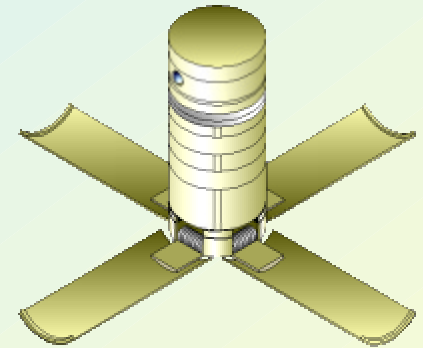
Warfighter will "see" where he currently cannot

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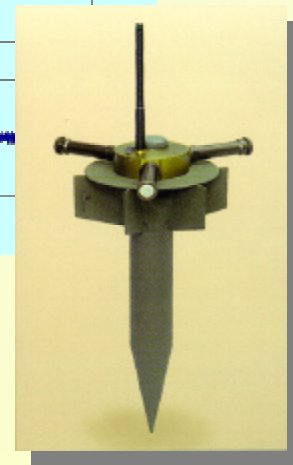# Acoustic / Seismic Sensors

- **360°, NLOS monitoring**
- **Provides LOB to targets**
- **Multiple nodes locate targets**
- **Detect & ID**
  - *Vehicles*
  - *Helicopters*
  - *Artillery, mortar, gunfire*
- **Excellent cueing for imagers**

Key Issues

> *Robust target localization*
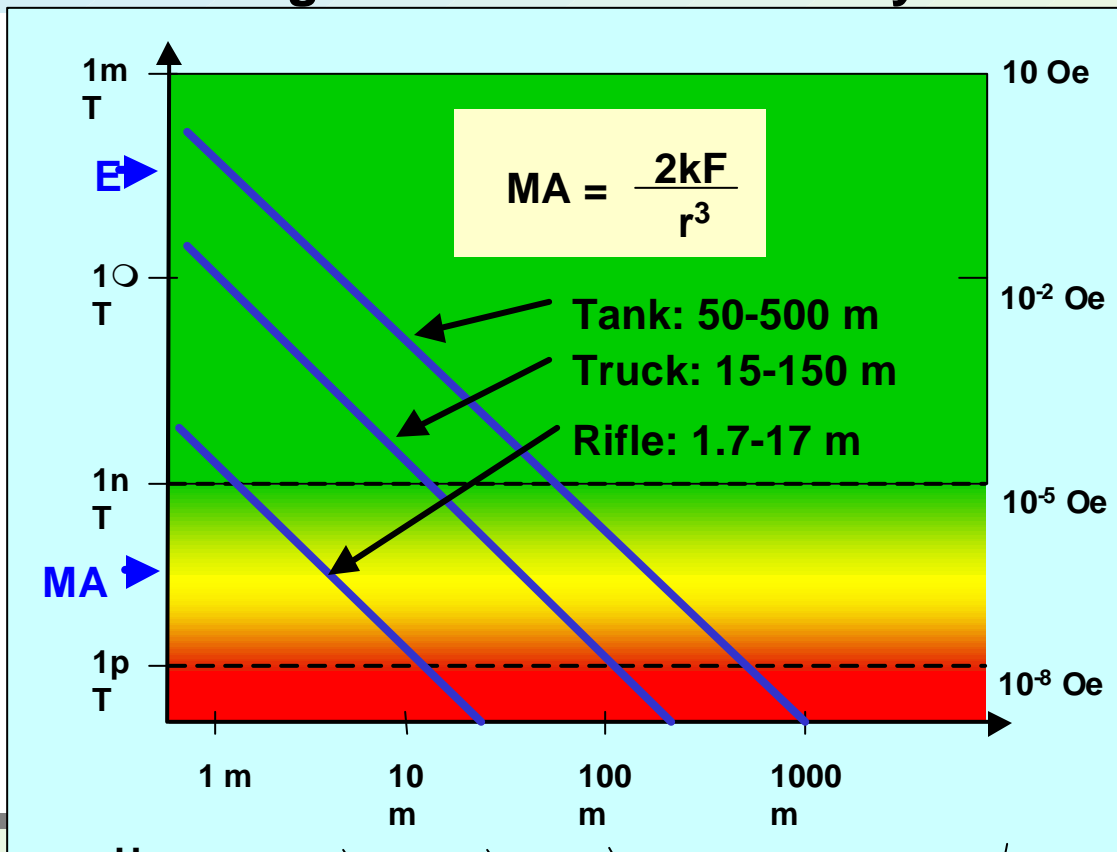> *Target identification*
> *Noise reduction*

Magnetic Sensors

- **Very low cost**
- **360°, NLOS monitoring**
- **All weather**
- **Detect**
  - *Vehicles*
  - *Small arms*
- **Excellent tripwire sensor to cue other sensors**

Magnetic Sensor Sensitivity

$$MA = \frac{2kF}{r^3}$$

Tank: 50-500 m

Truck: 15-150 m

Rifle: 1.7-17 m

1m T — 10 Oe
E
1 T — 10^{-2} Oe
1n T — 10^{-5} Oe
MA
1p T — 10^{-8} Oe

1 m   10 m   100 m   1000 m

H_z

H_y

H_x

Key Issues

- ➢ *Immature*
- ➢ *Noise reduction*
- ➢ *Low cost implementations*
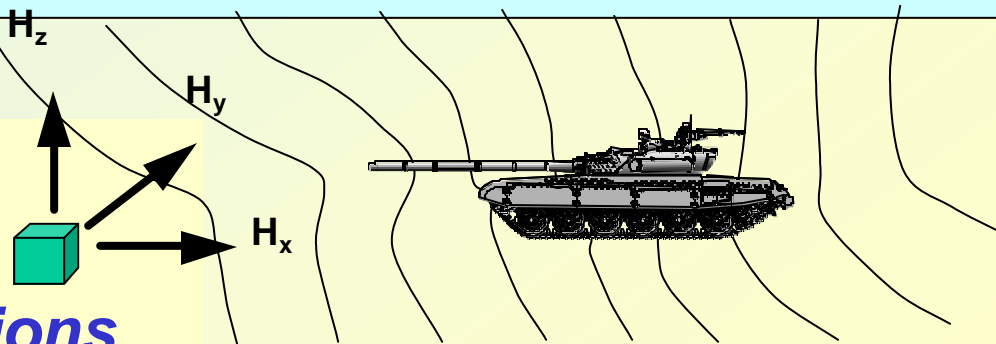
IR Sensors
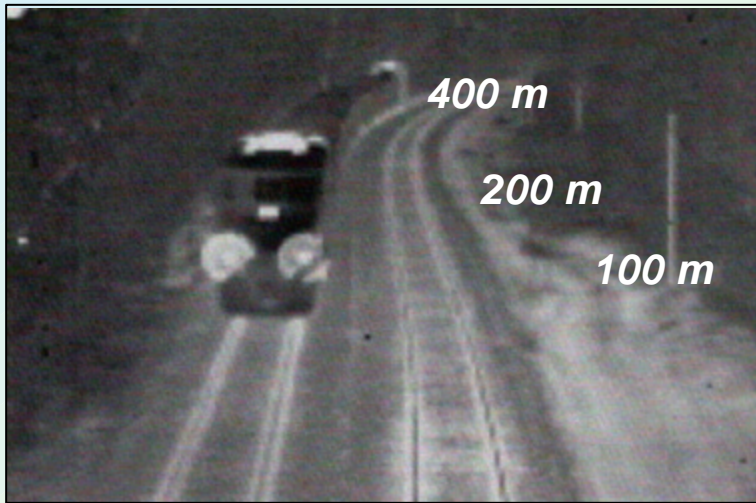
- **Low cost imager**
- **Low power / size**
  - *90 grams (including optic)*
  - *600 mW @ 3.5V*
- **Excellent target identification**

400 m

200 m
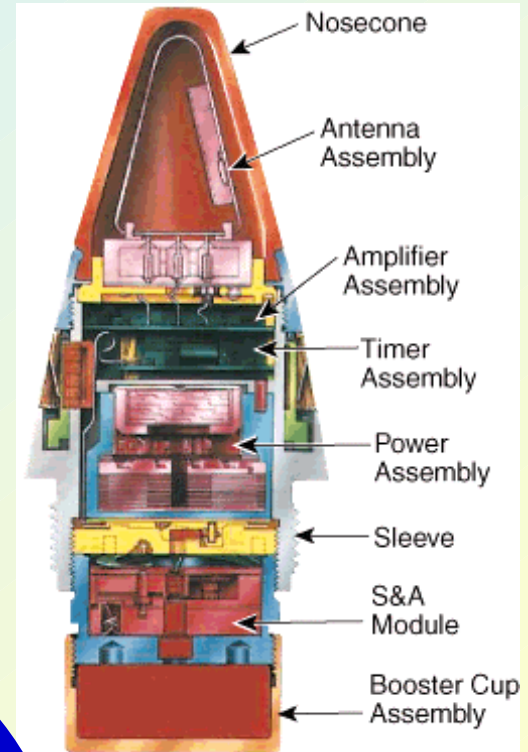
100 m

Key Issues

- ➤ *Robust automatic target recognition*
- ➤ *Lower cost – to be driven by commercial demand*
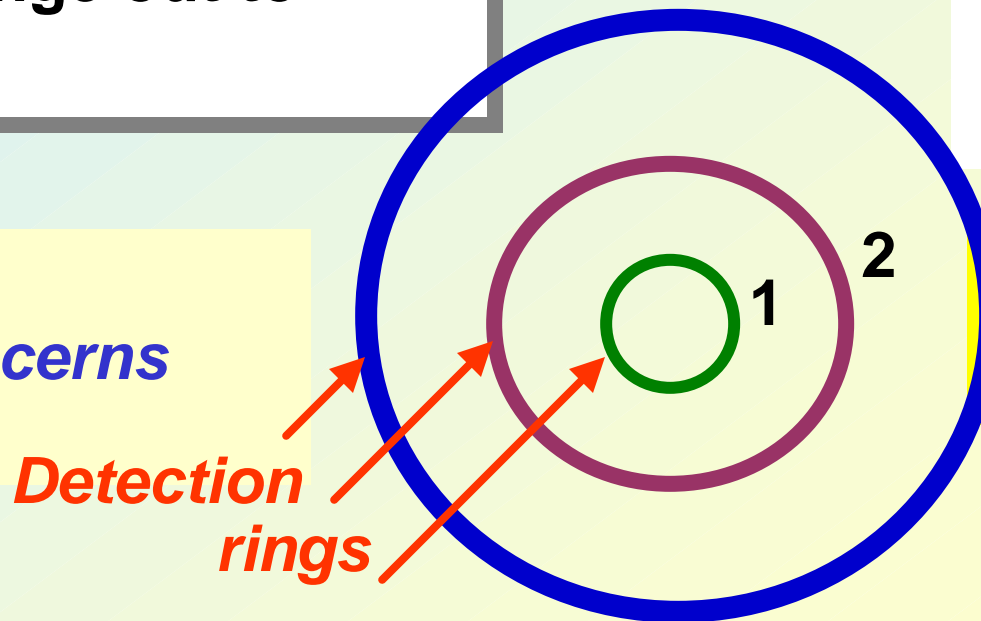
Moving Target Indicator (MTI) Radar Sensor

- **360°, NLOS monitoring**
- **Low cost**
- **Small, low power**
- **Detection of moving targets based on Doppler**
- **Target range out to > 500m**

$$P_r = \frac{P_t \, G_t \, G_r \, \lambda^2 \, \sigma}{(4\pi)^3 \, R^4}$$

Nosecone

Antenna Assembly

Amplifier Assembly

Timer Assembly

Power Assembly

Sleeve

S&A Module

Booster Cup Assembly

Key Issues

- ➢ *Immature*
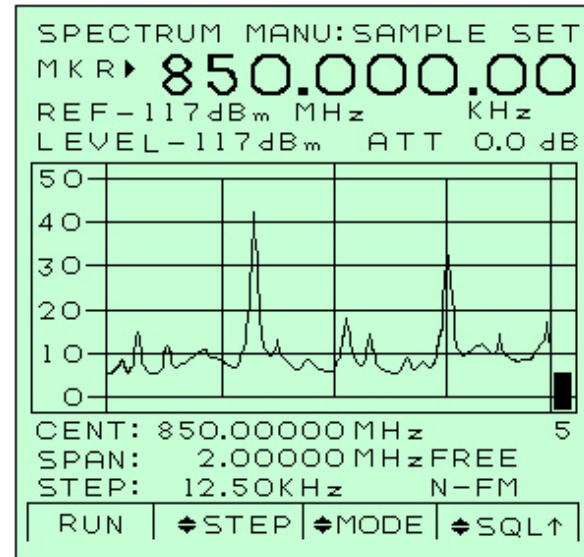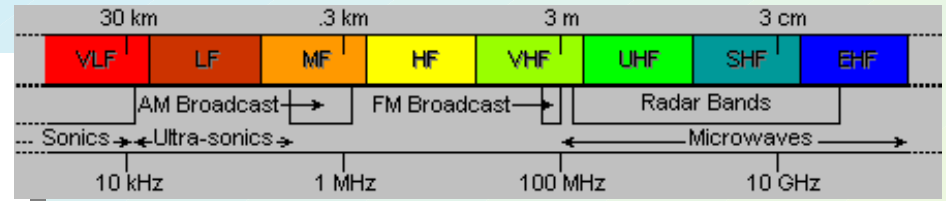- ➢ *Power concerns*
- ➢ *Cost*

1
2
3

Detection rings

Concepts based on Army proximity fuzes

RF Energy Sensor

- **Low cost**
- **Non-line of sight**
- **Small, low power**
- **Detects unintentional RF emissions**
  - *Engine noise*
  - *Electronics*
- **Detect & classify intentional RF signals**

SPECTRUM MANU:SAMPLE SET
MKR▶ **850.000.00**
REF −117 dBm MHz   KHz
LEVEL −117 dBm   ATT 0.0 dB

CENT: 850.00000 MHz   5
SPAN: 2.00000 MHz FREE
STEP: 12.50 KHz   N−FM
RUN | ⬍STEP | ⬍MODE | ⬍SQL↑

Key Issues

> *Immature*

> *Cost*

> *Wide frequency response needed*

Sensor Fusion

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Sensor Fusion Results

More than the sum of its parts

HIND Helicopter *(n-los)*

Light Truck
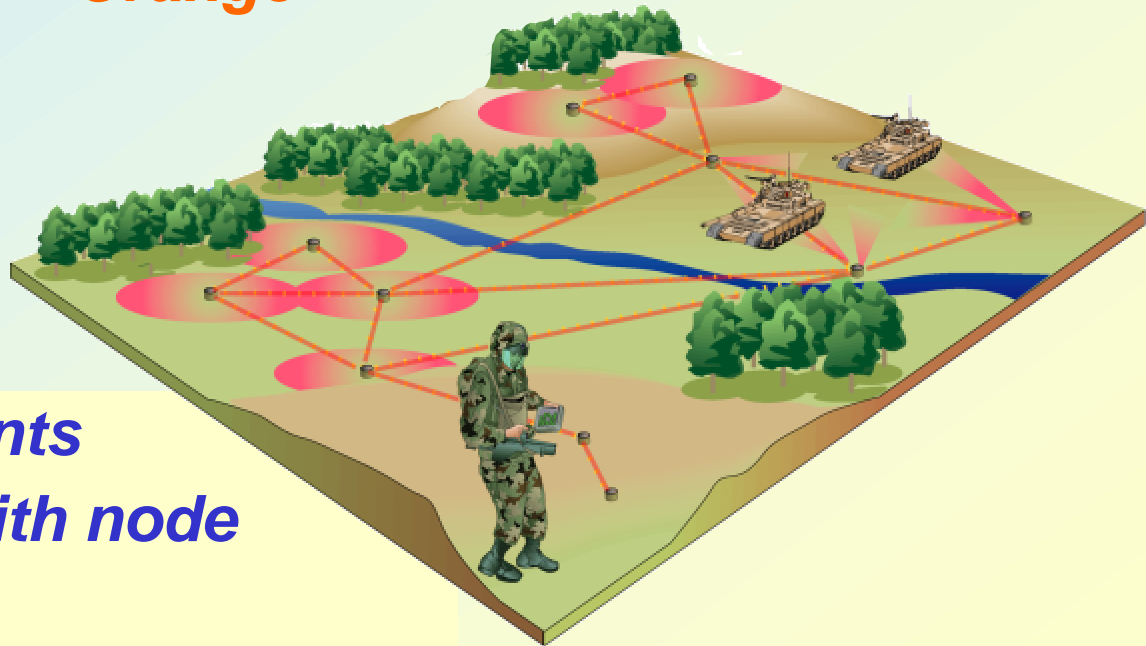
T-72

Heavy Truck

Tank

Dismounted
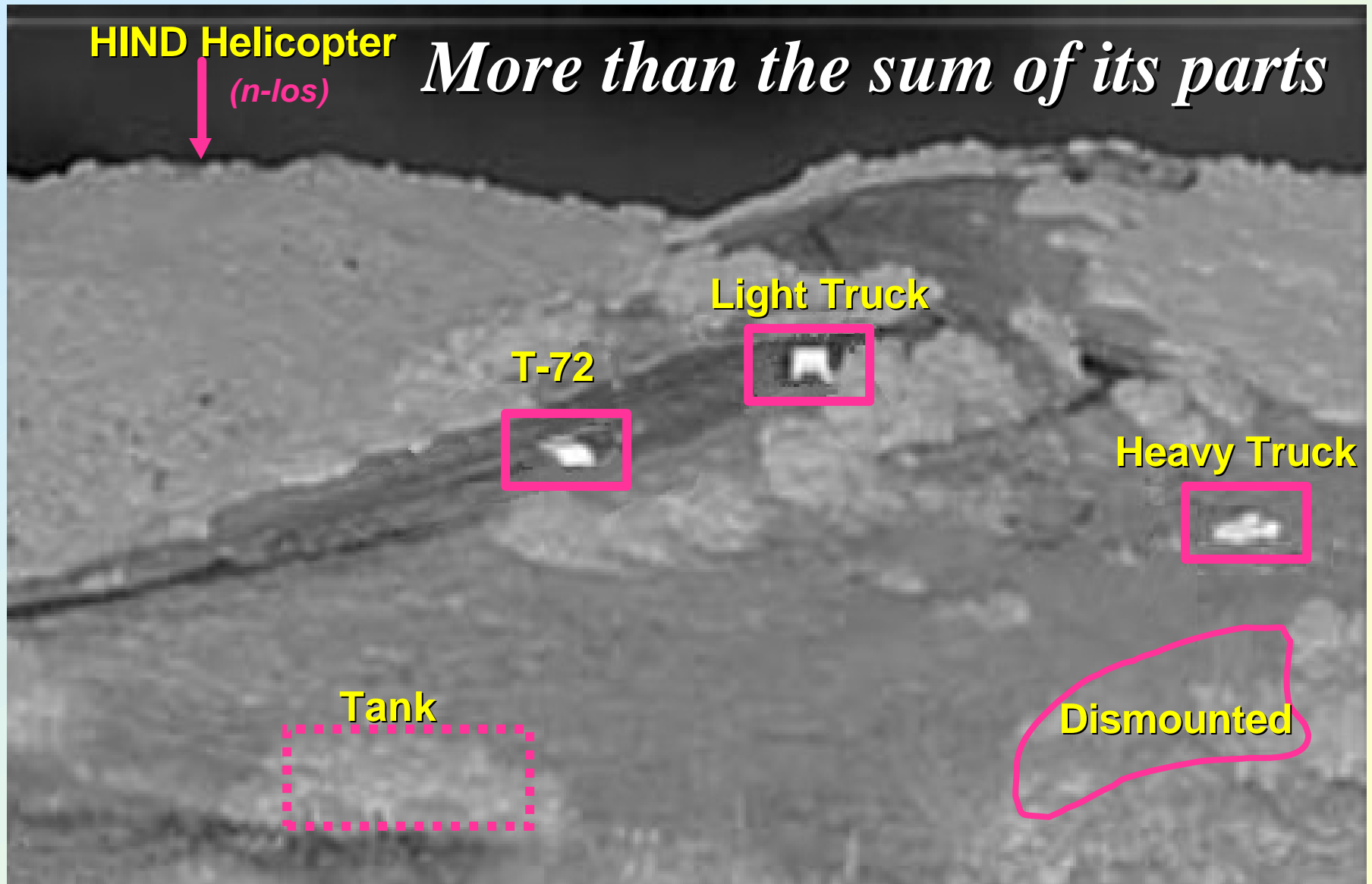
Communications

- **Key barrier to implementation of UGS networks**
- **Two types of comm links required**
    - *Local short haul radios - Blue*
    - *Long haul radios – Orange*

Key Issues

- *Bandwidth constraints*
- *Robust operation with node failures*
- *Mobility adds complexity*
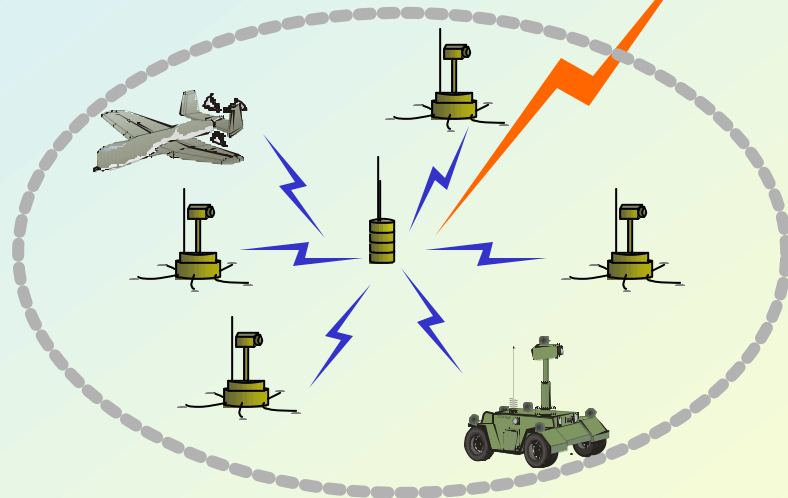- *Information protection*

Radios

- **Short Haul – inter-cluster "Blue"**
  - *Short range – 400 meters*
  - *Low bandwidth - <10Khz*
  - *Self-configuring, energy-aware*
  - *ComSec, LPI/LPD, anti-jam*
  - *Receiver energy can dominate power budget!*

- **Long Haul – cluster to C2 network "Orange"**
  - *Selectable BW – 1 khz data to video*
  - *Long range – 10 km or more*
  - *ComSec, LPI/LPD, anti-jam*

- **Must operate on noisy channels**

Self-Configuring Routing & Control

- **Linked Cluster *Ad Hoc* Routing Algorithm**

    - *Network self-organizes without prior knowledge of network*

    - *Adapts to mobility, channel effects, node failures*
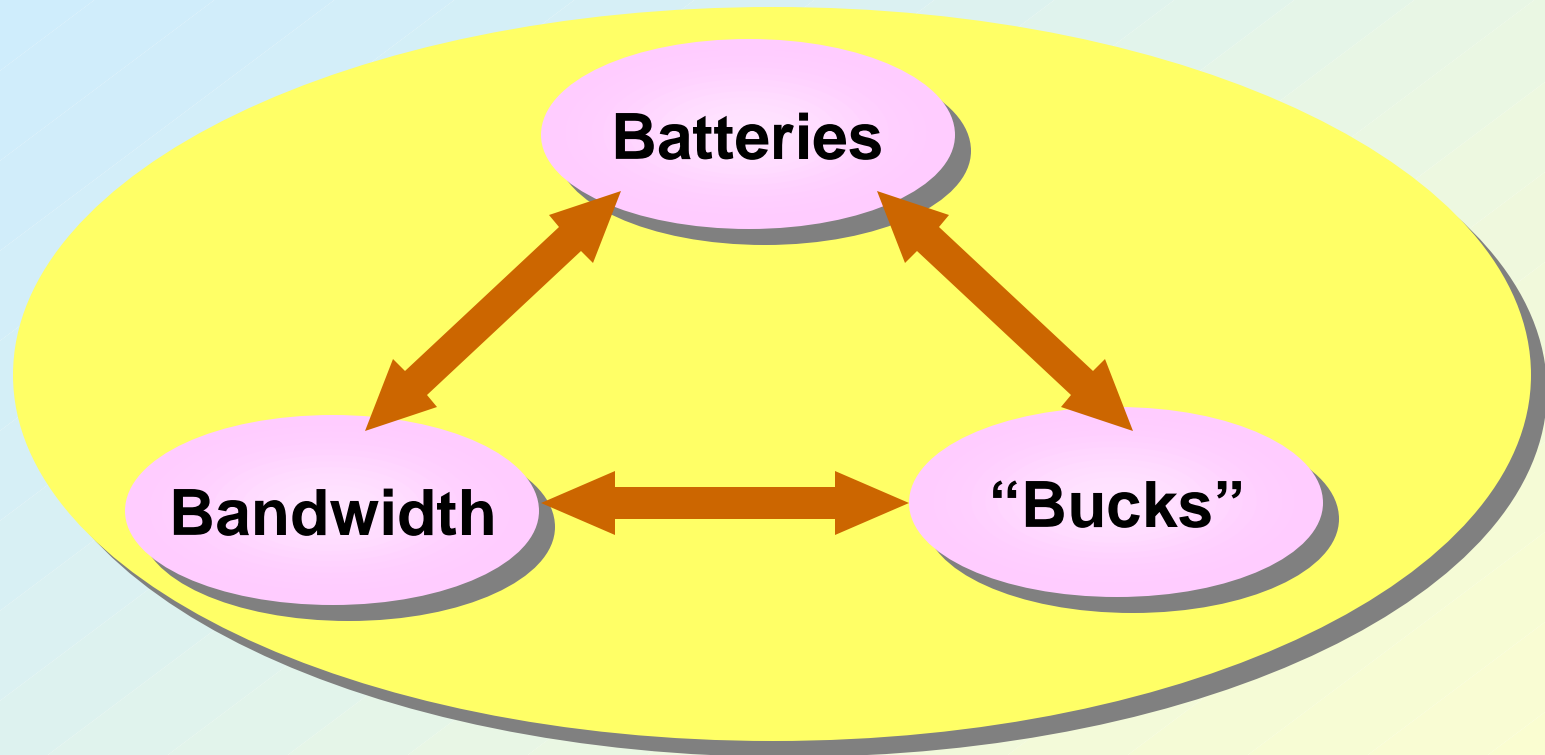
    - *Energy-aware routing & reconfiguration*

- **Control Architecture**

    - *Autonomously establishes & maintains the sensor network*

    - *Supports range of operational scenarios*

    - *Enables low-overhead security*
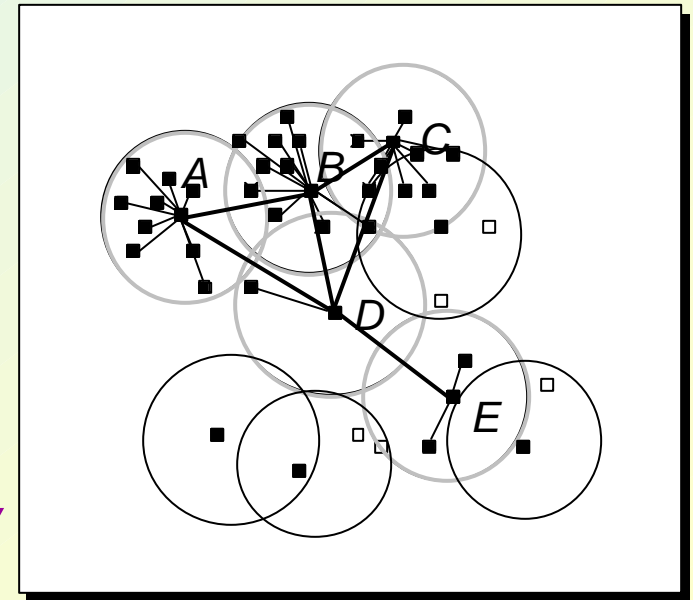
Modified Ephremides Linked Cluster Routing Algorithm

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Tradeoffs: "The 3 B's"
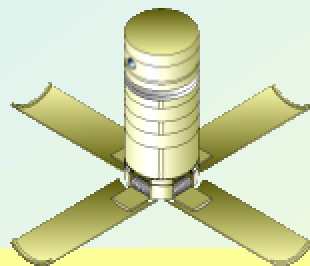
Batteries

Bandwidth

"Bucks"

Node performance tradeoffs are complex requiring careful consideration based on specific applications

Node Emplacement

- **Hand emplaced**
- **Artillery / mortar**
- **Aircraft / helicopters**
- **Mine dispensers**
- **Autonomous platforms**
  - *Small robots*
  - *Small UAVs*

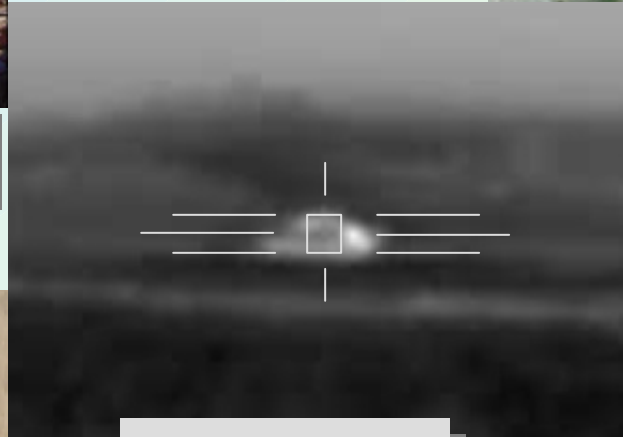**Small, autonomous platforms will allow sensors to position themselves to optimize sensing and/or communications**

Networked Sensor Applications

Perimeter Defense

Difficult Terrain

Tunnel Entrance

Assadalah Abdul Rahman's Camp

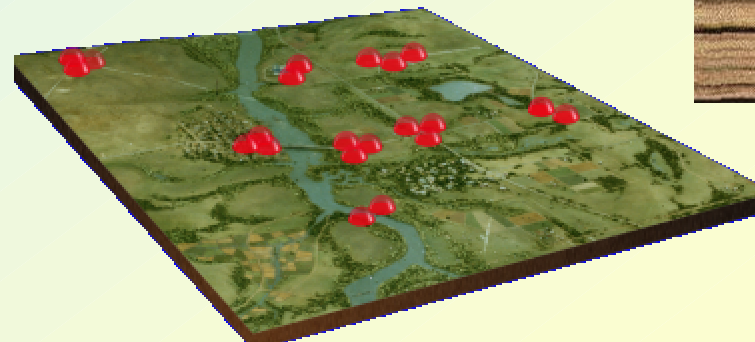**Targeting**

MOUT Operations

Personnel Detection

Networked Sensors for Indirect Fire Applications

Time Critical Targets

Hostile Artillery Location

Situational Awareness

Benefits of the Approach

- **Provide warfighters with <u>organic</u> capabilities down to small unit level**

- **Internetted, multi-sensor approach insures robust, reliable target information**

- **Range of employment mechanisms (*hand, air, munitions, robots*) enables diverse uses**

- **Range of low cost technologies will allow their rapid re-use to meet new requirements**

The Bottom Line

- **Army & other services are actively pursuing programs**

- **Many key technologies already exist**

- **Key challenges remain**

  - *Sensor & data fusion*

  - *Communications*

Not an <u>evolution</u>, but . . .
a <u>revolution</u> in battlefield sensing